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Agriculture

HERBICIDE SPRAY DRIFT

North Dakota Cooperative Extension Service
A. Dexter

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FACTORS AFFECTING SPRAY DRIFT

Spray particle size: Smaller spray droplets fall slower than larger droplets, so they drift farther and more easily (Table 1). Very small droplets - called "fines" - drift quite easily. One common objective of most drift control techniques is to eliminate these "fine" spray particles.

Methods of application: Herbicides are usually applied by airplane, helicopter, or ground sprayer. Ground sprayers are commonly used for herbicide application and are normally operated at 200 - 275 kPa pressure with 50 - 200 litres of water being applied per hectare.

Herbicide spray drift is greater from aerial application than from ground application when applied under similar environmental conditions. Ground sprayers generally produce larger spray droplets which are released from the nozzle closer to the target.

Nozzle height controls the distance a droplet must fall before reaching the crop. Less distance means less travel time and less drift. Wind velocity is often greater as height above the ground increases, so droplets from nozzles close to the ground would be exposed to lower wind speeds.

Herbicide volatility: All herbicides can drift in spray droplets, but some herbicides, depending on formulation and relative volatility, can also drift as a vapor (gas). For example, 2,4-D or MCPA esters are volatile and can drift as droplets or vapors, while 2,4-D or MCPA amines are essentially non-volatile and can drift only as droplets.

Vapor drift occurs when a volatile herbicide changes from solid or liquid into the gaseous state and moves from the target area. Herbicide vapor drifts farther and over a longer time than spray droplets. A wind blowing away from a susceptible crop during application will prevent damage from droplet drift, but a later wind shift could move damaging vapors into the field. Research has shown that 3 to 4 percent of both 2,4-D amine and ester drifted as an aerial cloud, but an additional 25 to 30 percent of the ester drifted as vapor in the first 30 minutes after spraying.

Relative humidity and temperature: Low relative humidity and/or high temperature will cause more rapid evaporation of spray droplets between the sprayer and the target than will high relative humidity and/or low temperature. Evaporation reduces droplet size, which in turn increases the potential drift of spray droplets (illustrated in Table 1). The influence of temperature and relative humidity on drift of small spray droplets is probably minor.

. . . 2

TABLE 1: INFLUENCE OF DROPLET SIZE ON POTENTIAL DISTANCE OF DRIFT

DROPLET DIAMETER (micrometres)	TYPE OF DROPLET	TIME REQUIRED TO FALL 3 m	LATERAL DISTANCE DROPLETS TRAVEL IN FALLING 3 m in a 5 km/h wind
5	Fog	66 minutes	5 km
20	Very fine spray	4.2 minutes	335 m
100	Fine spray	10 seconds	13 m
240	Medium spray	6 seconds	8.5 m
400	Coarse spray	2 seconds	2.6 m
1,000	Fine rain	1 second	1.4 m

Source: Klingman, Potts and Akesson and Yates

TABLE 2: RELATIVE DAMAGE TO TOMATOES FROM VAPORS RELEASED FROM 2,4-D FORMULATIONS HELD AT THREE TEMPERATURES

(Ratings taken 24 hours after exposure with 1 = no effect and 6 = severe damage)

	Temperature of 2,4-D formulation					
	22°C		32°C		49°C	
	Hours of exposure					
2,4-D formulation	2	16	2	16	2	16
Butyl ester (high volatile)	3.5	6.0	5.8	6.0	6.0	6.0
Butoxyethanol ester (low volatile)	1.0	1.0	2.3	5.7	5.5	6.0
Dimethylamine (non volatile)	1.0	1.0	1.0	1.0	1.1	1.2

Source: Baskin and Walker

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Temperature also influences the volatility of herbicides. Research information shows the vapor formation from a high volatile ester of 2,4-D would approximately triple with a temperature increase of from 15 to 26°C. At 26°C the vapor formation from the high volatile ester would be about 24 times greater than the vapor formation from a low volatile ester of 2,4-D.

An experiment to test the vapor damage to tomato plants from various formulations of 2,4-D at different temperatures showed vapors from high volatile esters caused injury to plants at all temperatures. The low volatile esters did not damage plants at 22°C but did at temperatures of 32°C and 49°C. Even though low volatile esters of 2,4-D are much less volatile, vapor drift from low volatile esters could still cause damage to susceptible plants. The amine formulation was essentially non-volatile, as no damage-causing vapor was produced even at high temperatures (Table 2).

These results indicate that a low volatile ester would begin to release damaging vapors at a temperature between 24 and 32°C. However, soil surface temperatures are often much warmer than air temperatures, especially on a sunny day, so vapor drift from low volatile esters may still occur at air temperatures lower than 24°C.

Wind direction: Herbicide should not be applied when the wind is blowing toward an adjoining susceptible crop or a crop in a vulnerable stage of growth. Wait until the wind blows away from the susceptible crop or, if weed problems are minor, don't spray at all. If herbicide must be applied while the wind is blowing toward a susceptible crop, use all possible drift control techniques, including, perhaps, using a ground sprayer rather than an airplane.

Wind velocity: The amount of herbicide lost from the target area and the distance it moves both increase as wind velocity picks up, so increased wind velocity will generally cause more drift. However, severe drift injury can occur with low wind velocities, especially under temperature inversion situations.

Air stability: Air movement largely determines the distribution of spray droplets. Lateral air movement (wind) is generally recognized as an important factor, but vertical air movement is often overlooked. In the normal "lapse" situation, air temperature decreases 3°C for each 500 m of altitude. Cool air tends to sink, displacing lower warm air and causing vertical mixing. If the "lapse" condition is greater than normal - greater than a 3°C decrease per 500 m vertical mixing will be greater.

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Another possibility is temperature inversion, where cool air is near the surface under a layer of warm air. Under inversion conditions, little vertical mixing of air occurs, even with a wind. Spray drift is most severe under inversion conditions since small spray droplets will fall slowly and will also move with any wind into adjoining areas. With the "lapse" condition the small spray droplets are carried aloft where they are dispersed. Research has shown that three times more spray drifted 30 - 60 m and 10 times more drifted 300 - 600 m under inversion conditions as compared to "lapse" conditions with a given wind speed.

Spray drift may occur even with relatively calm conditions under an inversion, especially with small droplets. Some of the most severe drift problems have occurred with low wind velocities, inversion conditions could be reduced by increasing droplet size by using large orifice nozzles and/or lower spray pressures.

Avoid applying herbicides near susceptible crops during temperature inversion conditions. Inversions can often be identified by obvserving smoke from a smoke bomb or fire. Smoke moving horizontally close to the ground would indicate a temperature inversion.

Spray pressure: Spray pressure influences the formation of droplets from the spray solution. The spray solution emerges from the nozzle in a thin sheet, and droplets form at the edge of the sheet. Higher nozzle pressure causes the sheet to be thinner, and this thinner sheet breaks up into smaller droplets. Larger orifice nozzles with higher delivery rates produce larger droplets than smaller nozzles.

Nozzle spray angle: Spray angle is the angle formed between the edges of the spray pattern from a single nozzle. Nozzles with wider spray angles will produce a thinner sheet of spray solution - and smaller spray droplets - than a nozzle with the same delivery rate but narrower spray angle. However, wide angle nozzles are placed closer to the target than narrow ones, and the benefits of lower nozzle placement outweigh the disadvantage of slightly smaller droplets.

Spray angle relative to direction of travel can also influence drift - especially with aerial applications. Because of greater wind shearing when the nozzles are pointed into the wind, nozzles pointed toward the direction of travel will produce smaller droplets than nozzles pointed back. The smallest droplets are produced from nozzles 45 degrees forward of vertical, with the largest produced by a straight-back (90 degree) orientation.

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Nozzle type: Droplet sizes produced depend on nozzle type, spray pressures and litres per minute output (Table 3). "Flat fan", "flood" and "hollow cone" nozzles produce similar sized droplets and a similar volume of small droplets. The flood nozzle tends to produce a wider range of droplet sizes than the flat fan, while the flat fan produces slightly larger droplets than the hollow one.

Two types of Raindrop nozzles have been developed for drift control. The type "RA" is a whirl chamber nozzle with a secondary swirl chamber attached. The type "RD" is a disc-core nozzle with a secondary swirl chamber attached. Compared with the other nozzle types listed in Table 3, the Raindrop nozzles produce the largest droplets and also the lowest volume of small droplets.

Air movement around aircraft: "Vortices" are irregular drafts of air around the fixed wing of airplanes or the rotary blades of helicopters. Updrafts are produced by the fixed wing or rotor tip, while downdrafts are produced by the body of the aircraft. The vortices move spray particles aloft with updrafts and down into the target area with downdrafts (Figure 1). Strength of the vortices is related to the weight and airspeed of a given aircraft. Increased airspeed and increased weight boost the strength of the vortices, raising the chances of potential drift.

A spray boom which covers no more than three-fourths of the distance from the center of the aircraft to the end of the wing or rotor tip will limit the spray released into the updrafts and reduce potential drift. Lowering the spray boom 30 cm or more below the wing of fixed-wing aircraft or moving the boom as far forward as possible on helicopters also reduces the exposure of spray droplets to vortices.

Proper spacing of nozzles to reduce drift and achieve uniform application varies with the type of airplane. Nozzles should generally be closer together near the end of the boom, with a one metre gap on the left of center and three or four nozzles grouped to the right of center. Air drawn by the propeller will spread the spray from the clustered nozzles into the area lacking nozzles, forming a uniform pattern. Spray distribution should be regularly tested, with the nozzle spacing adjusted to produce a uniform spray pattern if necessary.

A summary of the influences of various factors on spray drift is given in Table 4.

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TABLE 3: INFLUENCE OF NOZZLE TYPE AND SPRAY PRESSURE ON DROPLET SIZE

Nozzle type	Delivery rates L/min	Spray pressure kPa	Spray angle (degrees)	Volume median diameter micrometres)	Volume with less than 100 micrometres (per cent)
Flat fan	0.45	100	65	239	
(LF-2)	0.64	200	76	194	
	0.76	275	80	178	17.5
Flood	0.45	100	90	289	
(D-1)	0.65	200	115	210	
	0.76	275	125	185	15.5
Hollow cone	0.45	100		228	
(HC-12)	0.64	200		185	
	0.76	275	70	170	19.0
Whirl chamber	0.45	100		195	
(WRW-2)	0.64	200		158	
	0.76	275	120	145	23.0
Raindrop	0.45	100		539	
(RA-2)	0.64	200		381	
	0.76	275	120	330	1.0
Raindrop	0.42	100		506	
(RD-1)	0.58	200		358	
	0.68	275	90	310	0.8

Source: Delavan Manufacturing Company

TABLE 4: SUMMARY OF INFLUENCES OF VARIOUS FACTORS ON SPRAY DRIFT

FACTOR	MORE DRIFT	LESS DRIFT
Spray particle size	smaller	larger
Release height	higher	lower
Wind speed	higher	lower
Spray pressure	higher	lower
Nozzle size	smaller	larger
Nozzle orientation (aircraft)	forward	backward
Nozzle location (aircraft)	beyond 3/4 wing span	3/4 or less wing span
Air temperature	higher	lower
Relative humidity	lower	higher
Nozzle type	produce smaller droplets	produce larger droplets
Air stability	inversion	lapse
Herbicide volatility	volatile	non-volatile

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REDUCING DRIFT POTENTIAL

Ways of reducing potential drift from aerial application include: (1) flying as low as possible; (2) locating nozzles away from wing or rotor tips; (3) placing the spray boom well below the wing of airplanes or as far forward as possible on helicopters; (4) orienting nozzles backward; (5) spacing nozzles to produce a uniform pattern; (6) using low nozzle pressures; (7) using larger orifice nozzles, and (8) spraying when winds are light and the air is cool.

Spray drift in general can be reduced by: (1) avoiding spraying when drift-promoting environmental conditions exist; (2) using herticides which do not produce damaging vapors; and (3) using spray techniques and equipment which produce large droplets that are released close to the target.

Large spray droplets can be produced in several ways. Increasing nozzle orifice size and lowering spray pressure will each increase average droplet size. Change nozzles to increase volume per hectare rather than raising spray pressure or reducing travel speed. Increasing pressure boosts the percentage of small droplets, or fines, that are more likely to drift.

The Raindrop nozzle and the LP (low pressure) nozzle were developed to increase droplet size and reduce fines. These nozzles can be used on conventional spray equipment and will reduce drift potential.

Spray drift can also be reduced by modifying the spray solution. An invert emulsion spray system applies the herbicide in a "mayonnaise-like" material. The equipment required to produce an invert emulsion is of special design and not easily adapted to many agricultural uses.

"Nalco-Trol" is an additive which causes the spray solution to become more viscous, causing larger spray droplets. Nalco-Trol is for use in conventional spray equipment. The amount to add to the spray tank is critical. Too little will not control drift and too much will cause the spray pattern to collapse. Follow directions on the container.

There are several mechanical methods of producing uniform droplets but none has been widely adapted for agricultural uses. Future developments may produce a practical and adaptable method of applying herbicides without drift.

Drift control techniques which produce large droplets can reduce the effectiveness of any herbicides that require good coverage and small droplets to be effective. Barban (Carbyne) is an example of a herbicide requiring small droplets and should not be applied using drift control nozzles or additives that produce large droplets. Herbicides most likely to cause drift injury to broadleaf crops

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are 2,4-D, MCPA, dicamba (Banvel) and picloram (Tordon). Weed control from these herbicides is not reduced by application in large droplets if an adequate volume of water is used.

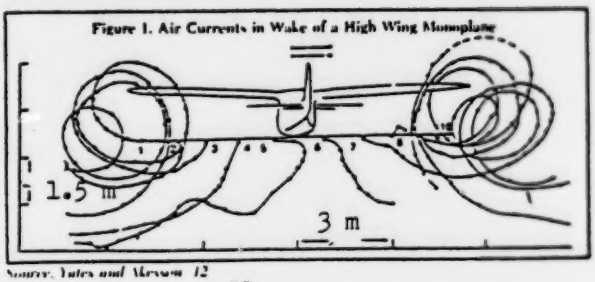

Figure 1. Air Currents in Wake of a High Wing Monoplane

Source: Yates and Akesson 12